Engineers Australia
Engineering Heritage Victoria

Nomination

Engineering Heritage Australia, Heritage Recognition Program

for the

WHEELERS BRIDGE,

Lawrence, 9 km north of Creswick, Victoria

A Pioneer of the Monier Concrete Arch Construction Method

April 2013

Front Cover Photograph Caption

Wheelers Bridge in 2012 taken from the upstream side on the southern bank of Birch Creek looking towards the north-west.

Despite Monash's unbounded confidence in the appropriateness of reinforced concrete the piers of this bridge are bluestone.

The underside of the arch reveals two problems which 113 years of service have illuminated; the dark mark is water draining from the spandrel fill. Water in this fill is thought to have contributed to expansion of the fill which has caused outward swelling of the spandrel walls. The other problem is spalling of concrete from the underside of the arch. The good practice rules for cover over reinforcement had not yet evolved at the time of construction of the Monash & Anderson Monier bridges. By modern standards the cover was inadequate. Both these problems are entirely repairable using present-day concrete technology.

Image: Redsoxdesign Dec 2012

TABLE OF CONTENTS

PAGE

1 Introduction

Engineering Heritage Victoria (EHV) has a sub-program within its Heritage Recognition work to recognise structures built by General Sir John Monash, the firm Monash and Anderson or later iterations of companies with which Monash was associated as a contribution towards the celebration of the centenary of the ANZAC Campaign in 2015. Heritage recognition ceremonies already accomplished in this regard are:

- Janevale Bridge at Lannecoorie in Central Victoria
- Yallourn Power Station in the Latrobe Valley
- Fyansford Monier Arch Bridge near Geelong

Wheelers Bridge is significant as it was one of the earliest bridges built by Monash & Anderson to the Monier Patents in Victoria [1]. Anderson Street Bridge (Morell Bridge) in Melbourne [2] and Fyansford Bridge in Geelong were slightly earlier.

Another motivation for concentrating effort onto Wheelers Bridge in 2013 is that the council which owns it, Hepburn Shire Council has announced in a Media Release that it intends to "replace " the bridge as part of an ongoing program to remove old bridges from its inventory. EHV hopes to engage the council in the Heritage Recognition of Wheelers Bridge which may assist in reinforcing the importance and value of the bridge.

It is apparent that the bridge is in quite good condition except for the usual problem with Monier arch bridges that the spandrel walls have been pushed outward by the pressure of the soil fill. The parapet walls are mass concrete and have suffered from traffic accident damage (particularly the south western end above the abutment) and there is a general outward displacement of the walls as a consequence of the spandrel wall movement.

There is some spalling of concrete on the underside of the arches (primarily near the abutments). The concrete cover in this area was extremely limited so it is not surprising that some spalling has occurred in 113 years of service. This needs to be repaired however it is probably of little significance structurally.

It has been suggested to the Council that the installation of a reinforced concrete deck incorporating replacement parapet walls would increase the load capacity of the bridge whilst providing a mechanism for dealing with the spandrel wall expansion problem. If this work was done in a manner sympathetic to the heritage values of the bridge the current load limit of 15 tonnes could be removed and the bridge could be expected to carry out its existing country road function for another 100 years.

[1] It is the oldest Monier arch bridge still in service carrying motor traffic. The Morell and Fyansford Bridges are now used for pedestrian traffic.

[2] Monash and Anderson did not design or build the Morell Bridge although Monash & Anderson had some minor part in the project.

2 Heritage Award Nomination Letter

The Administrator
Engineering Heritage Australia
Engineers Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of work: Wheelers Bridge

The above-mentioned work is nominated for an award under the Engineering Heritage Recognition Program.

Location, including address and map grid reference if a fixed work: On the Creswick to Lawrence Road, 13 km north of Creswick, Victoria. Grid reference:
30°19’23.12” S
143°53’29.6” E
Altitude = 1261 feet (385 metres)

Owner (name & address): Hepburn Shire Council, PO Box 21, Daylesford, Victoria 3460.

The owner has been advised of this nomination and a letter of agreement is attached at page 7.

Access to site: Bridge is on a public road with the surrounding land being farms.

Nominating Body: Engineering Heritage Victoria

OWEN PEAKE

Chair, Engineering Heritage Victoria

Date: 19 April 2013

2A Letter of Approval from Hepburn Shire Council

Hepburn Shire Council

Our Ref: fol/13/376

15 May 2013

Owen Peake
Chair Engineering Heritage Victoria
4 Islington Street
COLLINGWOOD VIC 3066

Dear Owen

Re: Heritage Recognition Ceremony – Wheelers Bridge 15 June 2013

Further to your letter of the 23 March 2013 and subsequent emails and phone calls, I confirm that Hepburn Shire Council approve of the recognition of Wheelers Bridge under the Heritage Recognition Program of Engineering Heritage Australia.

I also confirm that the ceremony will take place on Saturday 15 June 2013 at 10.00am.

Please do not hesitate to contact me on 5321 6426 if you wish to discuss this matter further.

Yours faithfully

BRUCE LUCAS
General Manager Infrastructure

Main office 76 Vincent Street, P.O. Box 21, Daylesford Vic 3460 Telephone (03) 5348 2306 Facsimile (03) 5348 2911
[illegible] Cnr Duke & Albert Streets, Daylesford Vic 3460 Telephone [illegible] Facsimile [illegible]
Service Centre 53 Albert Street, Creswick Vic 3363 Telephone (03) 5345 0090 Facsimile (03) 5345 0041
[illegible] Telephone (03) 5321 6120 Facsimile (03) 5321 6193
Website www.hepburnshire.com.au Email shire@hepburn.vic.gov.au
ABN 76 845 753 535

3 Heritage Assessment

3.1 Item Name: Wheelers Bridge

3.2 Other/Former Names: Some sources refer to the bridge as Wheeler's Bridge

3.3 Location: Creswick to Lawrence Road crossing Birch Creek, 13 km north of Creswick

3.4 Address: As above

3.5 Suburb/Nearest Town: Creswick

3.6 State: Victoria

3.7 Local Govt. Area: Hepburn Shire Council

3.8 Owner: Hepburn Shire Council

3.9 Current Use: Road bridge

3.10 Former Use: Road bridge (including pedestrian and bicycle use)

3.11 Designer: Monash and Anderson, Melbourne

3.12 Maker/Builder: Jenkins Bros, Ballarat and Monash and Anderson, Melbourne

3.13 Year Started: 1898

3.14 Year Completed: 1900

3.15 Physical Description: Monier arch bridge consisting of 2 spans of 75 feet (22.9 m)[3]

3.16 Physical Condition: The piers, abutments, approaches and arches are in good condition. Minor spalling on the underside of the arches is expected as the original concrete cover was minimal. This damage should be repaired to protect the reinforcing steel however the damage is not considered serious in structural terms as this reinforcement is virtually redundant in this design of bridge.

The spandrel walls are swelled from internal pressure from the fill, and the parapet walls have been displaced by the movement of the spandrel walls and by vehicle impacts in three locations. The movement of the parapet walls has the effect of opening a gap between the road pavement and the wall which in turn leads to water entering the spandrel fill. This is a vicious circle of cause and effect as the fill is apparently expanding when wet.

3.17 Modifications and Dates: In April 1900 there was concern over the state of the spandrel walls which had shifted outwards due to pressure of the fill. Monash and Anderson argued that the cause was the inadequacy of materials supplied by the Council however

[3] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Wheelers Bridge, Dossier summary, page 2.

Monash and Anderson agreed to pay just over half of the cost of the repaired. In August 1900 the spandrel walls were rebuilt and iron cross-ties were inserted prior to backfilling.[4]

No major repairs are known to have been carried out in the following 113 years.

3.18 Historical Notes:

3.18.1 The original bridge

A bridge at the site was proposed by Mr F Grundeman in January 1864[5]. This was to be a toll bridge which would eventually become the property of the Corporation. This bridge was under construction by April 1864[6] and had apparently been completed and opened for service by July 1864[7]. This bridge, with some later modifications remained in service until shortly before the building of the present Monier arch bridge in the period 1899-1900

3.18.2 Preliminaries for the Monier bridge

This project was initiated largely by J.T.N. Anderson while Monash was preoccupied with legal cases interstate. After his return from Perth in July 1899, Monash gradually took over supervision of construction and liaison with the client Shire and its Engineer.

In May 1898 Carlo Catani, the Chief Engineer of the Department of Public Works of Victoria, reported on the dilapidated state of the old Wheeler's bridge. This 2 span bridge had been erected in 1864[8] and consisted of a timber superstructure with stone abutments and pier. About 1887 the level of the deck had been raised some 2.7m by extending the pier and abutments. By 1898 these were distressed, and the timbers were rotting. Conventional options for replacing the bridge, as proposed by Catani were (a) a timber bridge of four spans with a total length of 47.5 m, costing about £900 and (b) a single stone arch with a span of 15.2m costing about £2750. However, on 14 May the Shire Engineer, Mr W. H. Gore, accompanied by his father, visited Monash & Anderson to discuss the possibility of using Monier arches.

Gore's father had seen Monier arches during a visit to Italy and heard favourable reports from Italian engineers. He had previously been Shire Engineer for Creswick, but seems to have been working for the Public Works Department about the time of his visit to Monash & Anderson. He told Monash & Anderson that he and his son had been sent by Catani.

Between 21 and 24 June 1898, Monash & Anderson prepared a drawing showing four alternative Monier schemes. Agreement was reached to develop a design with two spans, each 75 feet clear (22.9m). The resulting drawing and specifications were presented to Council on 6 July 1898, about the time that Monash left Melbourne to take part in a legal case in Western Australia. This proved to be much more prolonged than expected, and apart

[4] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Wheelers Bridge, Dossier summary, page 3.

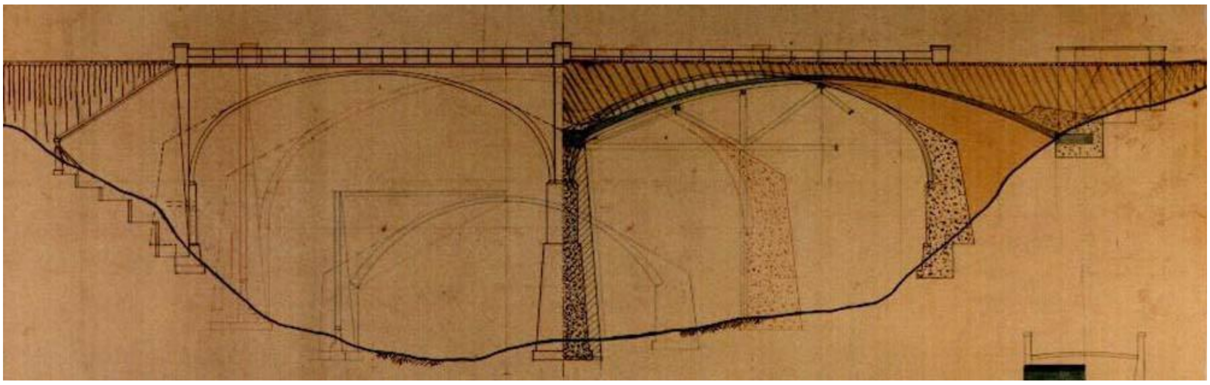
[5] The Star, Ballarat, Friday 29 January 1864, p4d.

[6] The Star, Ballarat, Friday 29 April 1864, p2d.

[7] The Star, Ballarat, Friday 15 July 1864, p4d.

[8] Refer clause 3.18.1 above.

from attending a militia training camp the following Easter, he did not return to Victoria until about 4 July 1899. Thus Anderson must have been wholly responsible for subsequent consultations with the Shire Council and its Engineer and the technical design of the bridge. Carter Gummow & Co. in Sydney carried out independent designs as a check, but not all their advice was accepted by Anderson. (This led to some friction as Gummow and his chief designer, William Julius Baltzer, tended to adopt a more cautious approach.)



Drawing of June 1898 by Monash & Anderson showing various alternative designs for Wheelers Bridge

Image: From Alan Holgate website.

Monash & Anderson estimated the cost of the bridge and approach works at £2450. Initially they hoped to undertake the entire project themselves, but Anderson's attempts to raise financial backing were unsuccessful. Furthermore Gummow, who controlled the license for this form of construction, preferred that Monash & Anderson tender for the Monier arches alone, and they themselves had begun to fear that their quotation was pitched too low. Anderson therefore negotiated an agreement by which he adopted the initial role of consultant to the Shire, responsible for preparing the specification and drawings. The overall contract was won by Jenkins Bros of Ballarat at a price of £3300 and work commenced on site about December 1898.

3.18.3 Construction.

Disputes erupted immediately between the Contractors on the one hand and the Shire Engineer and his inspector, Mr S Jory, on the other. These concerned the quality of Victorian versus imported cement, of sand obtained from nearby mines, and of the stones removed for re-use from the pier of the old bridge. The Contractors proposed modifications to the structure which they argued would save money without reducing its strength, and could not understand why the Shire Engineer would not accept them. They became concerned that extra work was being ordered without adequate documentation. They accused Gore and Jory of "pure malice" and of demanding impossibly high standards in materials and workmanship. Gore in his turn accused the contractors of trying to "work points" and skimp on standards. There were suggestions that Jenkins Brothers had realised they had bid too low, and were trying to slide out of the contract. Matters were complicated by Gore's continuing ill-health. Anderson was asked by both sides for advice and support as an impartial authority and his efforts to remain aloof were not entirely successful.

Despite these vicissitudes, Jenkins Bros did complete the substructure of the bridge: the foundations, abutments and the mass concrete 'skewbacks' on which the ends of the arches

would rest. They also built the centering: the timber structure that would support the wet concrete of the arch, although not to the satisfaction of Monash & Anderson. In September 1899 a special gang of Monash & Anderson's workers, directed by Anderson himself, cast the first arch strips, comprising half the width of the bridge over both spans. However, disputes and difficulties continued and in October 1899 the Council terminated the contract and Jenkins Bros withdrew.

By this time Monash had returned from Western Australia, and he conducted the negotiations which led to Monash & Anderson taking over to complete construction on favourable terms. He made his first recorded visit to the actual works on 29 December 1899 and gradually took the greatest share of responsibility as Anderson concentrated his attention on other projects. To complete the bridge it was necessary to build spandrel walls along the edges of the arches and fill the space between with rammed earth to form the roadway. Because of heavy commitments elsewhere, the firm had difficulty in arranging for competent on-site supervision of this portion of the work. Their trusted foremen Chris Christensen was discontented for various reasons, including the presence of assistant engineer Arthur Timmins on site. To placate Christensen, Timmins was replaced by Herman Roth, Monash's cousin and clerk to the partnership. Some records suggest that Council staff took more responsibility for operations than was defined by their official role. Disputes and problems concerning the sourcing and quality of cement and concrete continued even under the partnership's direction.

Monash made regular visits to the site until the bridge was completed early in March 1900. The load test and opening ceremony took place on 30 March 1900 in the presence of the Minister, the Hon George Graham, Messrs Peacock and Grose, MLAs, the ex-President of the Shire Mr A L Nase, Councillors of the Shire and Borough of Creswick, a Mrs Springfield, and Monash and his wife. The event was reported in the Argus as follows[9]:

> “Advantage was taken by the municipalities of Creswick borough and Creswick shire of the presence of Mr. Graham, the Minister of Public Works in the Ballarat District on Friday last to arrange for the testing and formal opening of the new Wheeler's bridge, near Creswick, built on the Monier principle. The Ministerial party, which was conducted through the district by Mr. Peacock and Mr. Grose, M.L.A.'s, proceeded by train to Creswick and was driven thence to the site of the bridge at Lawrence. The official test took place immediately, and consisted of running several times over the whole of the roadway two heavy traction engines, weighing in all 22 tons. The bridge, which consists of two spans each of 75ft., with a width of roadway of 24ft., withstood the test to the entire satisfaction of all concerned, Mr. Graham remarking that it was a highly creditable piece of work, and marked a distinct era in municipal engineering practice. After the test, Mr. Graham was entertained at luncheon by the president of the Creswick shire, and, in replying to the toast of his health, highly complimented the district for its enterprise. The bridge, whose total cost was a little over £4,000, was erected by Messrs. Monash and Anderson, of Melbourne”.

3.18.3 Early Problems

[9] The Argus, Melbourne, Tuesday 3 April 1900, p4.

Within a month of the opening ceremony, concern arose over the safety of the spandrel walls which were bulging outwards. Monash & Anderson denied responsibility, arguing that inadequacies in materials and construction were due to interference by Council staff. However, they agreed to contribute slightly more than half the costs of repair, as long as they were left entirely to their own devices. In August 1900 the walls were demolished and reconstructed, partly in masonry, and strengthened with iron cross-ties before back-filling. Unfortunately, disputes arose over the adequacy of the repairs and the quality of finish. Monash & Anderson provided a formal five-year guarantee, but local attitudes remained soured.

3.18.4 Later Life

Little is known about the maintenance of the bridge after 1900 or about any incidents involving the bridge.

The bridge still stands after 113 years in service and carries light traffic with a nominal 15 tonne load limit. It is very likely that heavier traffic still uses the bridge despite the load limit. It is apparent that there have been several incidents causing damage to the parapet walls by vehicle impact. The aesthetics of the bridge are somewhat spoilt by the damage and displacement of parts of the parapet walls[10].

3.19 Heritage Listings

3.19.1 Heritage Victoria

Heritage Victoria does not have Wheelers Bridge listed in its Victorian Heritage Register

3.19.2 National Trust of Australia (Victoria)

Name: Wheeler’s Bridge, Lawrence
Level: Regional
Register Number: B6805
Date Classified: Covering letter dated 18 June 1997

3.19.3 Hepburn Shire Council Heritage Overlay

Name: Wheeler’s Bridge, Lawrence Road, Lawrence
Level: Registered
Heritage Overlay Number: HO896
Date Classified: Not known

Details[11]:

[10] Observation by Owen Peake on site on 5 March 2013.

[11] Extracted from Hepburn Planning Scheme, Heritage Overlay Schedule, p65.

External Paint Controls Apply?	Yes
Internal Alteration Controls Apply?	No
Tree Controls Apply?	
Outbuildings or fences which are not exempt under clause 43.01-4	No
Included on the Victorian Heritage Register under the Heritage Act 1995?	No
Prohibited uses may be permitted?	No
Name of Incorporated Plan under clause 43.01-2	
Aboriginal heritage place?	No

3.19.4 Australian Heritage Council - Register of the National Estate

The database for this register is no longer available online as a result of changes in Australian Government policies.

The Wheelers Bridge site in not included in the book version of the register published in 1981 - *The Heritage of Australia - An Illustrated Register of the National Estate*, The MacMillan Company of Australia.

4 Assessment of Significance

4.1 Historical significance:

See section 3.17 above for details of the history of this site.

The particular significance of this site lies in its place in the evolution of bridge building materials and methods. It was the third Monier arch bridge built in Victoria. The earlier bridges, the Anderson Street Bridge in Melbourne (later called the Morell Bridge) and the Fyansford Bridge came into service shortly before Wheelers Bridge.

Following the construction of 18 Monier arch bridges[12] by Monash and Anderson in Victoria the style of bridge changed to reinforced concrete girder bridges from about 1910 onwards. This technique remained the most popular type of construction of road bridges until the present day with some refinements such as the prefabrication of bridge beams.

Hence the Monier bridges can be said to stand at the change from predominantly masonry or timber bridges to reinforced concrete road bridges in Victoria.

Furthermore the designs of Carter Gummow and Co and Monash & Anderson have stood the test of time. Many of their Monier bridges are still in service more than a century after they were built. Whilst there was evolutionary change in the design of reinforced concrete structures we can now see the early Carter Gummow and Co and Monash and Anderson bridges as providing a very firm basis on which bridge design and construction in the 20th century was based.

4.2 Historic Individuals or Association:

See Appendix 3 for biographical information on:

1. John (later General Sir John) Monash
2. Joshua T N Anderson
3. Joseph Monier
4. Alan Holgate
5. James Henry Wheeler

4.3 Creative or Technical Achievement:

The Monier bridges built in Victoria were based on the Monier patents which came to Australia via W J Baltzer and a licence in the Australian Colonies was taken out by Carter Gummow & Co in Sydney. Monash & Anderson worked quite closely in association with Carter Gummow & Co in Sydney although there were disagreements between the two companies over design details on occasions.

Monash & Anderson carried out detailed design and construction supervision with considerable precision and there were apparently remarkably few problems with the early

[12] Alan Holgate, list of Arch Bridges. Note that one of the bridges was built much later, in 1913, after the Monash & Anderson partnership had been dissolved.

bridges built. For instance the main arches of the downstream half of the Fyansford Bridge were cast on successive days in 1899.

The bridges were not highly decorated by the standards of their time and it is clear from discussions between the councils and Monash & Anderson at Fyansford that additional decoration added to cost which was not attractive to the councils who were “stretched” for funds to build bridges.

The technical achievement can therefore be seen as primarily a systematic approach to the application of the patent design in a workman-like manner, constructed in relatively short timeframes in order to provide councils facing the need to expand and improve their road networks at the lowest possible cost.

It should also be noted that the Monier arch bridges were not strictly speaking ‘reinforced concrete’ in the modern sense. They were designed specifically so that the arches carried only compressive load [13] in such a way that the reinforcing served only an ancillary function of dealing with minor un-predicted localised tensile stresses in the arch. In other words the bridges could have been constructed without reinforcing.

4.4 Research Potential:

Considerable work has been done by researchers such as P F B Alsop and Alan Holgate on the work of Monash and Anderson. No particular areas for further research appear to be pressing however as new material is found further research will undoubtedly occur.
For instance in 2012 intelligence came to light suggesting that a cabinet full of Monash & Anderson drawings, not previously known of, and not currently in the public arena have been found. Careful scrutiny of these drawings may throw more light on the designs, methods and contractual issues relating to the work of the partnership.

4.5 Social:

The early 20th century saw a very rapid expansion of the road network in Victoria. This expansion led to the construction of very large numbers of bridges. When the Country Roads Board was formed in 1913 [14] it quickly started to standardise bridge design to allow the more rapid expansion of the road network.

The work of expanding the road network was fundamental to the social changes relating to the adoption of the motor car which started at the turn of the 20th century and accelerated rapidly after the Second World War. This was one of the most profound social changes of the 20th century, leading most families to own at least one car by the 1960s.

The bridges of the Victorian road network, most of them quite modest in size, were critical to the achievement of this social change. The key issue for this story is that most of these bridges were built of reinforced concrete which proved to be cheap, durable and resistant to fire damage. The Monash & Anderson Monier bridges mark the beginning of reinforced concrete bridges in Victoria and for this reason they should be recognised and preserved.

[13] Refer Appendix 8.

[14] Refer to VicRoads Web site. History of the CRB.

4.6 Rarity:

Monash & Anderson built 18 Monier arch bridges in Victoria between 1899 and 1913. 11 of these bridges survive, at least 4 have been demolished and a further 4 are uncertain [15]. It cannot therefore be said that these bridges are rare.

More importantly we need to work to ensure that the remaining bridges are maintained, preserved and protected.

4.7 Representativeness:

Wheelers Bridge is representative of the Monier Arch Bridges built by Monash and Anderson. It is amongst the oldest examples and is one of the larger of the remaining bridges.

4.8 Integrity/Intactness:

The bridge appears virtually as first constructed.

The only visible change is the addition of some cross-tie rods and apparently changed material in the parapet walls however these changes are known to have been made in the same year as the bridge was constructed [16].

It is known that this design of bridge tended to suffer bulging of the spandrel walls. This certainly occurred early in the life of Wheelers Bridge and appears to be still an active problem [17].

---

[15] Statement based on evidence from the Alan Holgate web site. All information was taken from the papers referenced in the table of Monier arch bridges. The bridges demolished are the First King Street Bendigo bridge [This was the bridge which failed under test]; Myrtle Street and Oak Street Bendigo and Ford Creek at Mansfield, demolished in 1972. The status of the following bridges is not stated in the material: Barbers Creek, Whittlesea; Wollert , Whittlesea; Scott Creek Culvert Moorabool and the Coliban Reservoir Spillway Bridge.

[16] Refer clause 3.18.3.

[17] Observation by Owen Peake on site 5 March 2013.

5 Statement of Significance:

5.1 National Trust of Australia (Victoria) [18]

"This bridge, with its two spans of 22.9 metres clear, was only the third completed in Victoria using the early "Monier" system of reinforced concrete, after the Morrell Bridge across the Yarra in Melbourne and the Fyansford Bridge near Geelong. Only six multi-span bridges of this type were built in Victoria. The importance of the bridge is enhanced by its connection with John Monash, later General Sir John and his business partner Joshua Thomas Noble Anderson, subsequently a prominent and colourful figure in Municipal Engineering in Victoria. The partnership acted as Victorian agent for the Monier system representing the Sydney firm of Carter Gummow & Co which held the Australian licence. The technology was transferred from Germany through the Sydney firm. Wheeler's Bridge has a fair claim to being the first in which Monash & Anderson took the leading role in both design and construction. The story of Wheeler's bridge is closely linked with that of the Creswick district. The Creswick-Lawrence road passes through an area rich in goldmines, some of them once again in operation. At the time of construction, large quantities of "English capital" were about to be invested and the road was expected to become a major artery. The Public Works Department and the local council felt that a substantial bridge would be required to carry heavy traffic. The bridge, with its tall central pier some 8 metres high is impressive in appearance when viewed from the banks of the creek. These have potential to be developed as an attractive tourist and picnic area".

5.2 Register of the National Estate (now downgraded to a non-statutory archive)

None found

6 Level of Significance:

State

[18] Extracted from the National Trust of Australia (Victoria) web page on 15 March 2013.

7 Interpretation Plan

7.1 Interpretation Strategy

The strategy for interpretation of the Engineering Heritage Works is laid out in the latest version of EHA's "Guide to the Engineering Heritage Recognition Program" [19]. The interpretation will be by marking the works with an appropriate level of heritage marker; a public ceremony to unveil that marker; and an interpretation panel which summarises the heritage and significant features of the works for the public.

This plan provides a summary of the proposals for design, content, location, manufacture and funding of the proposed interpretation.

7.2 Date for the Event

The ceremony should be held on **Saturday 15 June 2013** at 10 am

7.3 The Interpretation Panel:

The following will be incorporated into the design of the panel:

1) A title: **"Wheelers Bridge".**
2) A subtitle: **"An Early Use of Reinforced Concrete in Victoria".**
3) Logos of Engineers Australia and Hepburn Shire Council.
4) A small scale representation of the EHA marker plate.
5) The date and other details of the marking ceremony.
6) A web site reference to the availability of the full nomination on the EHA web page.
7) A QR code to the above reference.
8) Text for main text panels should be 30 point Arial Bold.
9) Minimum text size should be 24 point Arial Bold.
10) No map will be required on this panel.
7) Historic photographs will be used to illustrate the panel. Many historic photographs exist. Brief captions for each photograph and source references to be used with each photograph.
8) Original drawings exist and copies may be incorporated into the panel.

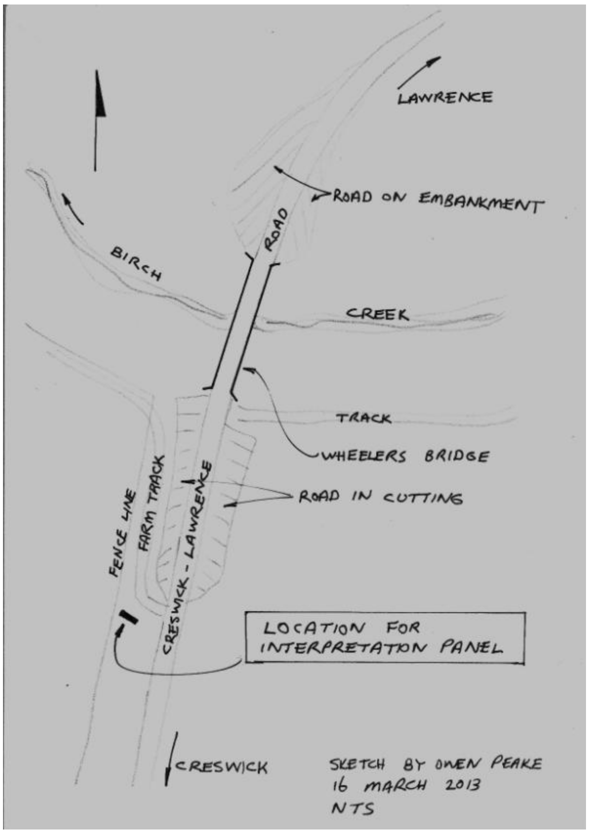
The interpretation panel will technically be constructed and erected as follows:

1) Size to be nominally 1200 mm wide by 600 mm high.

[19] The 2012 version. It should be noted that this version is not available on the Engineers Australia at the time of writing.

2) The panel to be constructed of vitreous enamel-on-steel plate with flanges as per drawing at Appendix 9.
3) The panel to be mounted on a steel free-standing frame as per Appendix 9.
4) The EHA marker (Engineering Heritage Marker) to be mounted below the interpretation panel as shown in Appendix 9.

The location of the interpretation panel has not yet been agreed with the Hepburn Shire Council, owner of the land on which it is to be erected however it is likely to be placed on the western side of the road south of the bridge on the high ground above the bridge, before the cutting in which to road approaches the bridge (see sketch below).



This will provide a view of the bridge from above (see image below) which is not ideal but better than other alternatives.

The possible locations for interpretation are severely limited by the local geography. Close to the bridge there are no places where the public could park off the road and observe an interpretation panel. There are no locations on public land (the road reserve) where a side-on view of the bridge is possible.

The approach from the south is more advantageous for interpretation as most traffic is likely to approach from the Creswick direction. Hence the western side of the road is safer for interpretation.

There is a wide, smooth verge on the western approach above the cutting and cars can stop clear of the roadway. The land is flat and suitable for erecting an interpretation panel.

The proposed location is shown on the diagram below. Note that the panel is likely to be located at least 100 metres from the nearest point of the bridge structure.

View from top of cutting south of the bridge. This is similar to the view which would be obtained from near the proposed interpretation panel location.

Image: Owen Peake

The panel will be mounted so that the bridge is in full view when the observer looks up from reading the interpretation panel.

The marker will be mounted on the crossbar of the interpretation panel stand and measures will be taken to secure it against removal by vandals by the installation of a “nut guard”.

7.4 Design Process for the Panel Content

The nomination will be reviewed during its development by the following parties:

1) The 10 members of the committee of Engineering Heritage Victoria

2) The Ballarat Regional Group of Engineers Australia Victoria Division

3) Mr Richard Venus, who is also the selected professional graphic designer for the project.

The design of the interpretation panel will be developed to the initial concept stage as part of the nomination writing process. It will then be further developed to a draft panel status by Richard Venus followed by review by the above reviewers plus the Heritage Recognition Committee and the site owner.

Manufacture will then be carried out by Glass Metal Industries, subject to availability of sufficient funding with the fall-back position being manufacture using vinyl film on aluminium by Advanced Group, Melbourne.

7.5 Funding

Funding for the interpretation panel is expected to be required as follows:

Item	Fund Source	Amount
Graphic Design including purchase of photographic rights	EHA National Budget	$500
Manufacture of panel by Glass Metal Industries	To be arranged	$1400
Manufacture of Steel Stand	To be arranged	$1000
Installation of panel stand and panel	To be arranged	$500
Supply from stock of marker by EHA	EHA National Budget	$200
	TOTAL	**$3600**

7.6 Draft Interpretation themes for Interpretation Panels

In accordance with good interpretation practice the content of the panel should be divided into three themes for ease of understanding by the public. In this case one of the themes has been split into two sub-themes as in c) and d) below. The following have been assessed as possible themes/sub-themes for the interpretation panel:

a) The role of John Monash and Joshua Anderson

b) The Building of Wheelers Bridge

c) From Pots to Ponts (The development of Monier arch bridges)

d) Why an Arch Bridge?

Total text should not exceed 500 words excluding headings.

7.7 Preliminary Text Blocks for Interpretation Panels

From Pots to Ponts

French horticulturist Joseph Monier devised a method of making flower pots and garden furniture by using a mesh of thin iron rods to reinforce concrete. He took out a patent in 1867 and continued to find new uses for the method which makes the best use of each material.

The technique was soon applied to other structures and in 1875 Monier designed the first iron-reinforced bridge (pont is the French word for bridge).

In the early 1890s the Sydney firm of Carter Gummow & Co acquired the rights to build Monier bridges in Australia.

In 1897 Monash & Anderson forged a link with them and obtained sole rights to the Monier patent in Victoria.

114 words

Building Wheelers Bridge

The first bridge on the site was built in 1864 and was constructed of timber. This bridge was raised by 2.7 metres in 1887 but was considered to be in a “dilapidated state” in 1889. By 1898 the bridge was reported to be “distressed and the timbers were rotting”.

In May 1898 Shire Engineer Gore visited Monash & Anderson to discuss the possibilities of using Monier arches at the site and by June Monash & Anderson had produced a drawing showing four alternative Monier schemes.

In December 1898 work commenced under a contract awarded to Jenkins Brothers of Ballarat. In September 1899 work had progressed to a point where a Monash & Anderson gang could start work on casting the arches. In October 1899 the Council terminated the Jenkins Bros contract and Monash & Anderson proceeded to complete the bridge which was achieved in March 1900.

The bridge wads load tested with a traction engine and the opening ceremony occurred on 30 March 1900.

164 words

Monash & Anderson

Wheelers Bridge was designed and partially built by Melbourne consulting engineers Monash & Anderson who started in 1894.

General Sir John Monash (1865 - 1931)

In 1905 John Monash started the Reinforced Concrete & Monier Pipe Construction Company which continued to develop the use of reinforced concrete in Victoria. Following a brilliant military career in World War I he became Chairman of the State Electricity Commission of Victoria and led the effort to use Latrobe Valley brown coal to generate electricity.

Joshua Anderson (1865 - 1949)

Joshua Anderson’s engineering career has been overshadowed by Monash’s military fame. Anderson worked in various disciplines, then went to New Zealand, and later worked as a municipal and consulting engineer in Victoria.

118 words

Why an Arch Bridge?

[Diagram of forces to be included as per Fyansford panel]

The graceful curve of an arch bridge transfers some of the weight of the bridge and its traffic into a horizontal force resisted by the abutments. Longer bridges may have several arches supported by piers in the middle.

People have been building arch bridges for thousands of years. They're simple, they work, and they can be quite pleasing in appearance.

To build a Monier arch bridge, timber formwork was erected and steel reinforcement put in place. The concrete was poured into the form - in1899 they used wheelbarrows. When the concrete had gained sufficient strength the formwork was removed.

99 Words

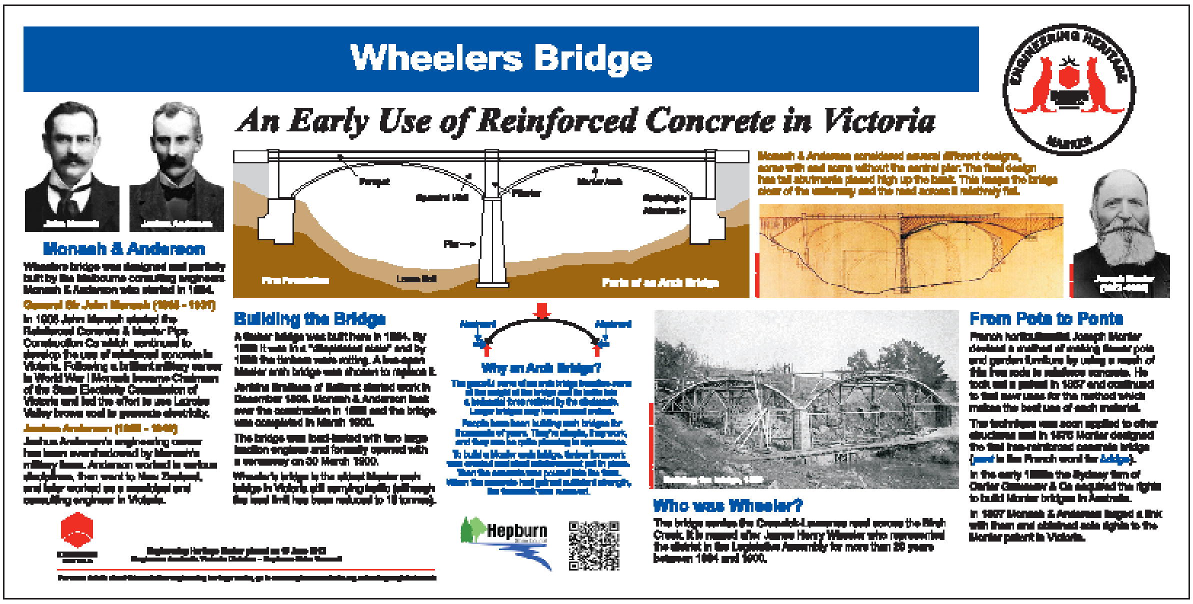
Who was Wheeler?

The bridge carries the Creswick-Lawrence Road over Birch Creek. This was an important gold-mining area in the late 19th century. It is named after James Henry Wheeler who represented the district in the Legislative Assembly for more than 20 years between 1864 and 1900.

44 words

Total word count = 539

A second draft of the proposed interpretation panel is shown below. This interpretation panel shares some common elements with the 2012 panel erected at Fyansford Bridge in Geelong.



8 References:

Holgate,A., Taplin,G., Alves,L. 'Wheeler's Bridge, Lawrence: Working Dossier'. Faculties of Engineering and Arts, Monash University, Clayton, Australia, April 1997.
ISBN 0-7326-1265-9. 58 pp.

John Monash, Engineering enterprise prior to WWI, Wheelers Bridge, Monier arch bridge at Lawrence, near Creswick, extracts from dossier
http://home.vicnet.net.au/~aholgate/jm/textys/whlrshist.html

Alves, L., Holgate, A., Taplin, G. 'Monash Bridges: Typology Study - Reinforced Concrete Bridges in Victoria 1897-1917', Faculties of Arts and Engineering, Monash University, Melbourne, 2nd edition, September 1998. ISBN 0-7326-1415-5. 144 pp.

Chamber's Technical Dictionary, W & R Chambers Ltd, Edinburgh and London, 1954.

Holgate, A. John Monash: promoting early reinforced concrete in Australia. Proc. Inst. Civ. Engrs., Engineering History and Heritage, 163, Nov. 2010, Issue EH4, 237-247.

Holgate, A. and Taplin, G. The Contribution of Sir John Monash to 20th Century Engineering in Australia. Proc Eleventh National Conference on Engineering Heritage, Institution of Engineers, Australia, Canberra, October 2001. (Republished in Australian Journal of Multi-Disciplinary Engineering, Vol.2, No.1, 2004, pp.99-107.)

Holgate, A., Taplin, G., Alves, L., and Hamann, C. The introduction of Monier arch bridges to Victoria. 'Proc. First International and Eighth Australian Conference on the Engineering Heritage', Newcastle NSW, 30 Sept. to 2 Oct., 1996. I.E.Aust., Canberra, 1996, pp.29-35.

Taplin, G. and Holgate, A. Monash, Anderson, transport and communication 1894-1914. Proc. Eleventh National Conference on Engineering Heritage, Institution of Engineers, Australia, Canberra, October 2001.

Taplin, G. and Holgate, A. Innovation in concrete technology - the contribution of Sir John Monash. Proc. Concrete Institute of Australia 2001 Conference, Perth, September 2001.

Nomination prepared by:

Owen Peake
FRMIT HonFIEAust CPEng
4 Islington Street
Collingwood Victoria 3066
Phone: +61 3 9419 0820 (home and work)
Email: owen.peake@bigpond.com

David Beauchamp
MICE MIEAust CPEng
159 Arnold Street
Princes Hill Victoria 3054
Phone: +61 3 9387 1708
Mobile: 0408 109 014
Email: david@beauchamp.biz

Appendix 1: Images with captions

A1.1 Historic Images

W

Wheelers Bridge being tested with a traction engine

Image: source not discovered

Guests at the Wheelers Bridge Opening Ceremony 30 March 1900. The man sitting in the centre of the photograph beside the two women is Sir Alexander Peacock, Premier of Victoria. John Monash is standing immediately behind Peacock in dark suit. Victoria Monash is sitting beside Peacock in dark dress. Others in the image are not identified.

Image: National Library of Australia

The Monash and Anderson Families 1897.

Left to right: Monash and Anderson standing.
The ladies are Victoria Monash and Ellen Anderson.
Alan Holgate thinks that this is Anderson's brother Jack.
The boy must be the Anderson's son, Stewart, born May 1893.
The girl on the left is Bertha Monash, born January 1892.
The girl on the right must be Frances Anderson, born November 1894.
The baby must be Alice Anderson, born June 1897.

Image: National Library of Australia

A1.2 Modern Images

Wheelers Bridge from the north east quarter in 2008

Image: Wendy Tonkin

Central pier, Wheelers Bridge, bluestone masonry, 2013

Image: Owen Peake

Southern span looking to south abutment showing water stains at join line between two cast parallel halves of the span. This indicates the presence of water in the spandrel fill.

Image: Owen Peake

Spalling of concrete and water stains on northern span abutment end.

Image: Owen Peake

The northern approach to the bridge showing the cutting on the far side. Note the narrowness of the road and the lack of pull-off opportunities close to the bridge.

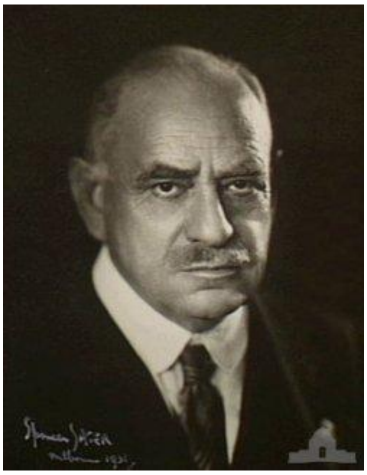
Image: Owen Peake

Appendix 2: Register of the National Estate entry for Wheelers Bridge

Not found

Appendix 3: Historic Individuals or Associations

A3.1 Sir John Monash (1865–1931) [20]



Sir John Monash

"John Monash was born in Melbourne on 27 June 1865 into a Prussian-Jewish family. He was educated at Scotch College and Melbourne University. By 1895 he had degrees in arts, engineering and law and had qualified as a municipal surveyor, an engineer of water supply and a patent attorney. As an engineer Monash's early career was in bridge construction working for a time with the Melbourne Harbour Trust, before becoming a partner in a bridge building firm. By the turn of the century his focus had changed to building construction. Monash's military career began in 1884 with his membership of the Melbourne University company of the 4th Battalion, Victoria Militia, and then moving to the North Melbourne Battery of the Metropolitan Brigade of the Militia Garrison Artillery. He was commissioned in 1887. By 1913 Monash had the rank of Colonel and was appointed to command the 13th Infantry Brigade. With the outbreak of World War I in 1914, Monash was transferred from the militia to active service. In 1915 he served as Chief Censor until taking command of the 4th Infantry Brigade (AIF). In this command he served at Gallipoli.

Promoted to Major-General, he commanded the 3rd Division, AIF in France in 1916. Monash succeeded General Birdwood as Australian Corps commander in 1918 and, in the same

[20] National Archives of Australia, http://www.naa.gov.au/aboutus/publications/factsheets/fs121.aspx, 1997. This document was copied from the Engineering Heritage Victoria Nomination for the Yallourn Power Station by Udara Almeida, 2011.

year, was knighted by King George V in recognition of his role in the Battle of Hamel Hill. With the conclusion of the war, Monash became Director-General of Repatriation and Demobilisation with responsibility for arranging the return of Australian troops from Europe. Back in Australia Monash resumed his engineering career firstly as General Manager and later as Chairman of the State Electricity Commission (SEC) of Victoria. Under his leadership the SEC became an important body in developing Victoria's brown coal reserves as an electricity source and, by 1930, extending the power grid across the whole of the State.

John Monash died in Melbourne on 8 October 1931."

A3.2 Joshua Thomas Noble Anderson (1865-1949) [21]

"John Monash's subsequent fame overshadowed the contribution made by J. T. N. Anderson to engineering in Victoria and to Monash's early career. The pair formed a business partnership in 1894. In 1897, while Monash was in Western Australia, Anderson forged a link with the Sydney firm of Carter Gummow & Co and obtained through them sole rights to the Monier patent in Victoria. He oversaw the initial negotiations, planning and design for the partnership's first two Monier arch bridges (Fyansford and Wheeler's); obtained many of their commissions and contracts; and consulted widely in the fields of mechanical engineering, water resources and mining. By 1902 a downturn in the economy and two serious misfortunes had placed the partnership in severe financial trouble and its future was uncertain. Anderson elected to take up a salaried position in charge of design and construction of a new sewerage scheme for Dunedin, New Zealand. It is likely that the pair hoped to form a bridgehead there for the partnership and its related pipe factory, though nothing eventuated. Monash worked in Victoria at trading the firm out of debt and in 1905 it was agreed that the partnership be dissolved. Anderson relinquished his rights and was absolved from his share of the remaining debt. He travelled overseas for some time, then returned to Australia and spent the rest of his life in municipal engineering in Victoria, while retaining his independence as a consulting engineer". [22]

[21] Alan Holgate Vicnet web site downloaded 10 July 2012.

[22] Anderson's life is summarised in a paper by Brian Lloyd. Stories of the bridge projects in which JTNA was concerned are available on the Alan Holgate web site via the following links: Morell Bridge; Fyansford Bridge; Wheeler's Bridge; Bendigo Arch Bridges; Kings Bridge, Bendigo; Barbers Creek Bridge and Woolert Bridge. There is much more in the archives at UMA and NLA on JTNA's consulting work, e.g. for the Mildura Irrigation Board and the Ballarat Woollen Mills.

A3.3 Joseph Monier (1823 - 1906) [23]

"Monier was born in Saint Quentin la Poterie, France and became a renowned French gardener and one of the principal inventors of reinforced concrete.

As a gardener, Monier was not satisfied with the materials available for making flowerpots. Clay was easily broken and wood weathered badly and could be broken by the plant roots. Monier began making cement pots and tubs, but these were not stable enough. In order to strengthen the cement containers, he experimented with embedded iron mesh. He was not the first to experiment with reinforced concrete, but he saw some of the possibilities in the technique, and promoted it extensively.

Monier exhibited his invention at the Paris Exposition of 1867. He obtained his first patent on July 16, 1867, on iron-reinforced troughs for horticulture. He continued to find new uses for the material, and obtained more patents — iron-reinforced cement pipes and basins (1868); iron-reinforced cement panels for building façades (1869); bridges made of iron-reinforced cement (1873); reinforced concrete beams (1878). In 1875 the first iron-reinforced cement bridge ever built was constructed at the Castle of Chazelet. Monier was the designer.

The important point of Monier's idea was that it combined steel and concrete in such a way that the best qualities of each material were brought into play. Concrete is easily procured and shaped. It has considerable compressive or crushing strength, but is somewhat deficient in shearing strength, and distinctly weak in tensile or pulling strength. Steel, on the other hand, is easily procurable in simple forms such as long bars, and is extremely strong. But it is difficult and expensive to work up into customized forms. Concrete had been avoided for making beams, slabs and thin walls because its lack of tensile strength doomed it to fail in such circumstances. But if a concrete slab is reinforced with a network of small steel rods on its undersurface where the tensile stresses occur, its strength will be enormously increased.

Francois Hennebique saw Monier's reinforced concrete tubs and tanks at the Paris Exposition and began experimenting with ways to apply this new material to building construction. He set up his own firm the same year and in 1892 he patented a complete building system using the material.

[23] Wikipedia, Joseph Monier, downloaded 10 August 2012.

In 1886 German engineer Gustav Adolf Wayss (1851–1917) bought Monier's patent and developed it further. He conducted further research in the use of reinforced concrete as a building material, and established the firm of Wayss & Freytag”.

A3.4 Dr Alan Holgate (1937 -) [24]

The research of Dr Alan Holgate has been vital to this nomination. His material is collected together in a systematic manner on a Vicnet web site making it very accessible. All students of Monash's work are indebted to Alan for his body of work on Monash.

Alan Holgate was born at Chesterfield, Derbyshire, England in 1937. He now lives at Mooroolbark, in the outer eastern suburbs of Melbourne.

He was educated in various primary schools in Derbyshire and Devon then moved on to Newton Abbot Grammar School, studied civil engineering at University College, London, from 1955 to 1958 and obtained a BSc(Eng).

He carried out supervision of road maintenance and construction with the Department of Main Roads, New South Wales from 1958 to 1961 then worked as Office Engineer at Marples Ridgway & Partners, London from 1961 to 1962.

Returning to Australia he worked on hard rock tunnelling supervision for the Snowy Mountains Hydro-Electric Authority, Eucumbene, Australia from 1962 to 1963 then in power station design, Snowy Mountains Hydro-Electric Authority, Cooma from 1964 to 1965.

He then took up teaching and research in analysis and design of structures with the Department of Civil Engineering, Monash University, Melbourne from 1966 to 1996. During this time he was a lecturer from 1967 to 1971, Senior Lecturer from 1972 to 1993 and Associate Professor from 1994 to 1996.

He obtained his Ph.D at Monash University in 1996 and since retiring from Monash has been in Independent Scholar.

[24] Alan Holgate Vicnet web site downloaded 10 July 2012.

A3.5 James Henry Wheeler (1826 - 1904)[25]

James Henry Wheeler

Image: State Library of Victoria

Wheeler arrived in Victoria in 1852 aged 26. He was a storekeeper at Forest Creek and erected a sawmill at Wombat Forest. Later he lived at Daylesford for many years and owned properties in Victoria and New South Wales. He was a Councillor of the Glenlyon shire and severed for a time as President. He also served on the council of Daylesford borough for many years including a time as mayor.

Wheeler served as MLA for Creswick from November 1864 until December 1867 and from May 1880 to March 1889 when he became MLA for Daylesford until October 1900. He was appointed Minister for Public Works and vice-president of the Board of Land & Works on 5 November 1890.

[25] Wheeler, James Henry, Parliament of Victoria website, www.parliament.vic.gov.au/re-member/bioregfull.cfm?mid=815, viewed 25 March 2013 – includes photo.

Wheeler was certainly present at a meeting held in September 1864 to discuss the forthcoming election for the Victorian Parliament. He was elected at the election as one of the two members for the district of Creswick.

In the period January 1864 to July 1864 a proposal had been made and adopted for the construction of a privately owned bridge at the site of present-day Wheelers Bridge. The proposal was reported on 29 January 1864 and work was reported to be in progress by 29 April 1864. In July 1864 the bridge was apparently in use as there was a dispute over the collection of tolls to use it and adjacent roads[26].

The timing of the completion of the bridge and the election of J H Wheeler to parliament make it very likely that the bridge was named after Wheeler.

A reference to floods in Birch Creek on 19 September 1870 refers to "Wheeler's bridge"[27].

> "The force of the torrent which raged along Birch's Creek during the flood on Thursday, 8th September, may be estimated by the fact that a large rock, upwards of six tons in weight, which was lying in the bed of the creek, near Wheeler's bridge, has been swept away".

References to Wheelers bridge continued through the period of service of the original bridge and up until the construction of the present bridge in 1899-1900[28].

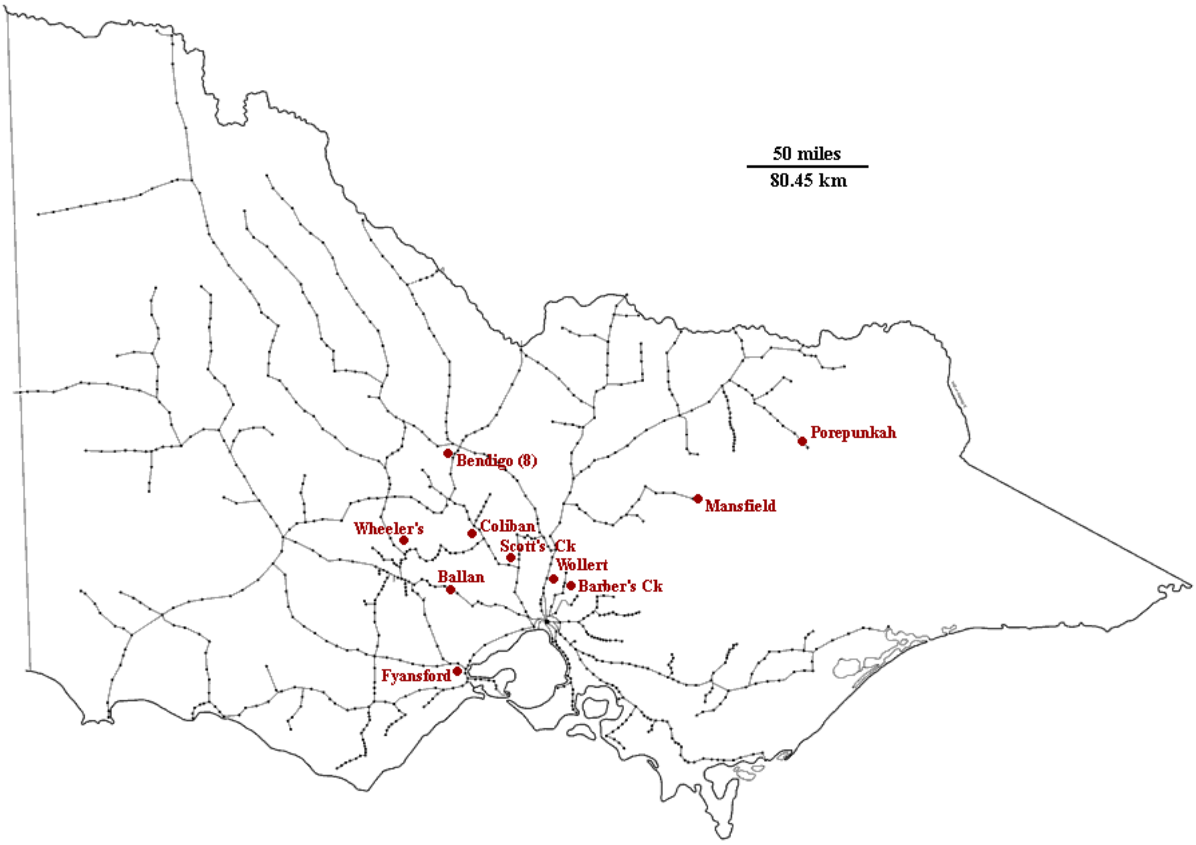
[26] Refer section 3.18.1.
[27] The Argus, Monday 19 September 1870, p7g

[28] Country News, The Argus, Saturday 20 January 1883, p4e*; The Argus*, Saturday 28 October 1899, p14f.

Appendix 4: Maps

A4.1 Location Map. Birch Creek over which the bridge carried the Creswick to Lawrence Road runs from right to left in this image. This image is scaled to represent a view from an altitude of 15,300 feet (4666 metres).

Image: Google Earth



A4.2 Map of Monier Arch Bridges built in Victoria.

Image: Alan Holgate Vicnet website

Appendix 5: List of Monash & Anderson Monier Arch Bridges [29]

Bridge Name	Date	Municipality (present)	Coordinates
Anderson St. "Morell." (attributed to Carter Gummow & Co.)	1899	Melbourne.	-37.8275, 144.9850
Fyansford.	1900	Greater Geelong-Golden Plains.	-38.1420, 144.3087
Wheeler's.	1900	Hepburn.	-37.3230, 143.8916
Oak St.	1901	Greater Bendigo.	
First King's.	1901	Greater Bendigo.	
Booth St.	1901	Greater Bendigo.	-36.769847, 144.261839
High St.	1901	Greater Bendigo.	-36.769628, 144.263867
Wade St.	1901	Greater Bendigo.	-36.77042, 144.26082
Scott's Ck Culvert.	1901	Moorabool.	
Second King's. (Weeroona Ave).	1902	Greater Bendigo.	-36.74364, 144.29165
Abbott St.	1902	Greater Bendigo.	-36.758347, 144.289917
Myrtle St.	1902	Greater Bendigo.	
Thistle St.	1902	Greater Bendigo.	-36.76837, 144.26710
Barber's Creek.	1901	Whittlesea.	-37.57440, 145.10448

[29] Alan Holgate, list of Arch Bridges.

Wollert.	1901	Whittlesea.	-37.59590, 145.05357
Coliban.	1902	Macedon Ranges.	-37.284840, 144.397248
Ford's Creek.	1903	Delatite.	
Ballan.	1905	Moorabool.	
Porepunkah.[30]	1913	Alpine.	-36.69700, 146.89393

[30] This bridge was constructed well after the Monash & Anderson partnership was dissolved in 1905.

Appendix 6: Time Line for John Monash [31]

1865	Birth - 27 June, at Dudley Street, West Melbourne
1874-75	Resides with family in Jerilderie, New South Wales
1877-81	Student at Scotch College
1882	Enrols at University of Melbourne
1884	Joins University Company of the Victorian Rifles, appointed Colour-Sergeant in 1886
1884-87	Employed on construction of Princes Bridge and other bridge works in Melbourne for David Munro & Co.
1887	Commission in the Militia Garrison Artillery
1887	Takes charge of construction works for Outer Circle Railway
1891	Marries Victoria Moss
1893	Master of Civil Engineering Birth of daughter Bertha
1892-94	Assistant Engineer and Chief Draftsman of Melbourne Harbour Trust. Qualifies as Municipal Surveyor, Engineer for Water Supply and as Patent Agent
1894-1905	Private Practice (Monash and Anderson) as Consulting Engineer and Patent Attorney
1895	Awarded Bachelor of Arts and Bachelor of Laws

[31] Monash University web site downloaded 10 July 2012.

1897-99	Legal-engineering work in Queensland, New South Wales and Western Australia
1901	Monier Pipe Company Pty. Ltd. formed (Monash, Anderson and Mitchell)
1905	Reinforced Concrete and Monier Pipe Construction Company Pty. Ltd. formed (Monash and Mitchell)
1907	Takes command of Victorian Section of newly formed Intelligence Corps
1908	Promoted to Lieutenant-Colonel
1912	President of Victorian Institution[32] of Engineers
1913	Appointed Colonel and commander of 13th Infantry Brigade in Victoria
1914	Leaves Australia in command of 4th Infantry Brigade, Australian Imperial Force
1915	Promoted to Brigadier-General
1916	Promoted Major-General in command of new 3rd Division
1918	Knighted by King George V
1918	Appointed Australian Corps Commander and promoted to Lieutenant-General
1919	Returns to Australia
1920	Death of Victoria Monash Appointed General Manager of the State Electricity Scheme

[32] Institute corrected to Institution for clarity.

1921	Awarded Doctor of Engineering Appointed Chairman State Electricity Commission
1921-31	Oversees design and construction of Shrine of Remembrance
1923	Chairman of Royal Commission into police strike
1923-31	Vice-Chancellor of the University of Melbourne
1929	Promoted to General Awarded Peter Nicol Russell Memorial Medal[33] (Institution[34] of Engineers, Australia)
1930	Awarded Kernot Memorial Medal (University of Melbourne) for brown coal development
1931	Death - 8 October

[33] Often referred to as the Peter Nicol Russell Medal.

[34] Institute corrected to Institution for clarity.

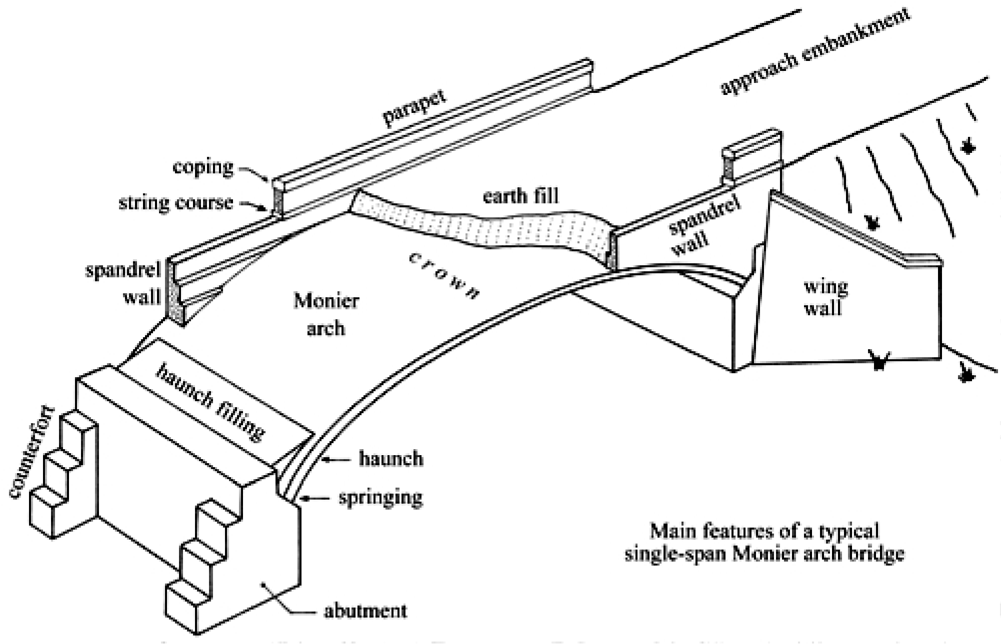
Appendix 7: Time Line for Wheelers Bridge [35]

1864	First bridge completed at the site.
1887	Bridge raised by 2.7 m by extending the piers and abutments.
May 1889	Carlo Catani reported on the dilapidated state of Wheelers Bridge.
1898	The bridge was "distressed and the timbers were rotting".
14 May 1898	Shire Engineer Gore visits Monash & Anderson to discuss possibilities of using Monier arches.
June 1898	Monash & Anderson prepare drawings of 4 alternative Monier schemes.
Dec 1898	Work commenced under contractor Jenkins Bros, Ballarat.
Sept 1899	A Monash & Anderson gang starts casting the arches.
Oct 1899	Council terminates the Jenkins Bros contract.
29 Dec 1899	John Monash makes first visit to the work site.
March 1900	Bridge completed.
30 Mar 1900	Load Test and Opening Ceremony.
August 1900	Repair work on spandrel walls carried out.

[35] Events extracted from John Monash, Engineering enterprise prior to WWI, Wheelers Bridge, Monier arch bridge at Lawrence, near Creswick, extracts from dossier
http://home.vicnet.net.au/~aholgate/jm/textys/whlrshist.html

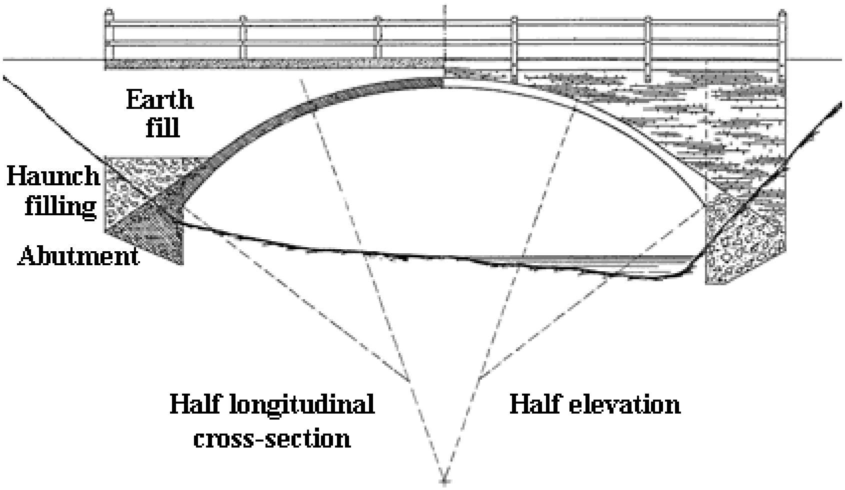
Appendix 8: Basic calculations for Monier arch bridges as carried out by Monash & Anderson. [36]

This web page is devoted to the procedures used by Monash and Anderson, and their engineering assistants, to determine the profile for a Monier arch, and to calculate the resulting forces and stresses. It assumes that the reader has some basic knowledge of the mechanics of structures. It is restricted to the techniques used for M&A's early bridges, which were checked only for symmetrical uniformly distributed live load. The Upper Coliban Spillway Bridge is used as an example. Computations were sent to Sydney to be checked by W. J. Baltzer and F. M. Gummow. Baltzer had earlier used more complex procedures for the design and analysis of the Anderson Street (Morell) Bridge. After the collapse of the first King's Bridge at Bendigo, Monash obtained from him details of procedures for analysis for non-symmetrical and point loads, the most important 'point' loads being the axles of the steam rollers used in testing the bridges.



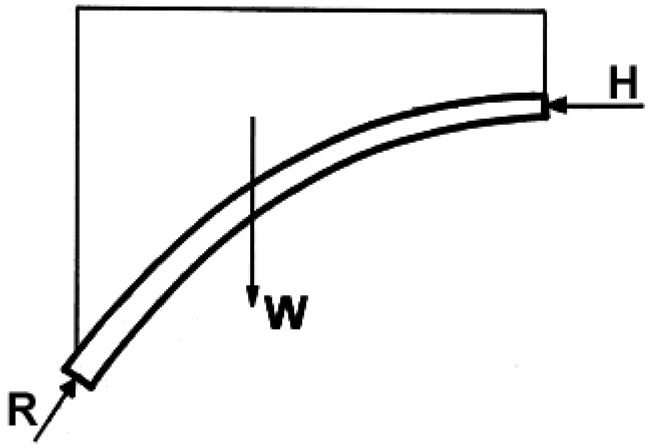
The process used for design was a sort of 'form-finding'. At this early stage in the development of reinforced concrete, M&A and their advisors were unaware of any method for taking into account the presence of the reinforcement in an arch cross-section subjected to combined axial load and bending moment. The grids of small diameter bars provided in the Monier system were therefore ignored in analysis, and the aim was to shape the curve of the arch to avoid tensile stresses under normal loading conditions. This was achieved by ensuring that the centreline of the profile coincided with the line of thrust due to the self weight of the arch, spandrel walls and filling. (Sometimes live load was included at this stage.) Checks were then made on varying live load conditions applied to the chosen form, to ensure that the thrust line did not deviate greatly from the centreline. Because the self weight of the bridge was enormous in comparison with the live load, this was rarely a problem in theory. (In practice it turned out that the arch curve as built often deviated considerably from the theoretical curve owing to deflection and subsidence of falsework, and this was a much more significant cause of bending stress.)

[36] Alan Holgate Vicnet web site downloaded 10 July 2012.

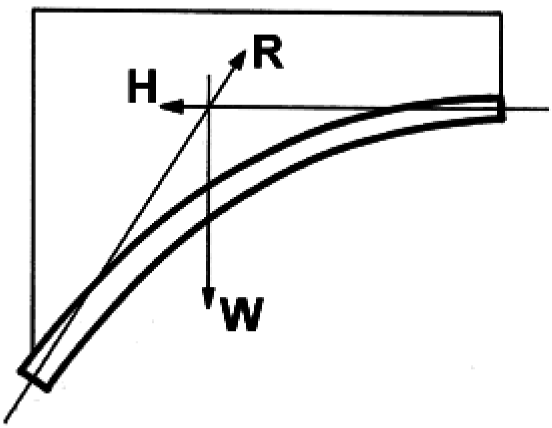


The left-hand side of the above drawing shows half of the longitudinal cross-section of a typical Monier arch bridge. The right hand side shows half of the side elevation. The arch profile is made up of three circular segments, as indicated by the radii. This is a simplified version of part of the working drawing for Ford's Ck Bridge, Mansfield. For a more complete extract click here.

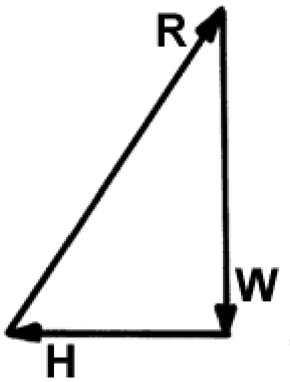
The process of form-finding was iterative. All bridges were assumed symmetrical about the vertical centreline of the elevation, so that one half of the span could be treated as a 'free body' subjected to three forces: W, the total weight; R, the inclined reaction from the abutment; and H, the thrust in the crown exerted by the other half of the bridge.



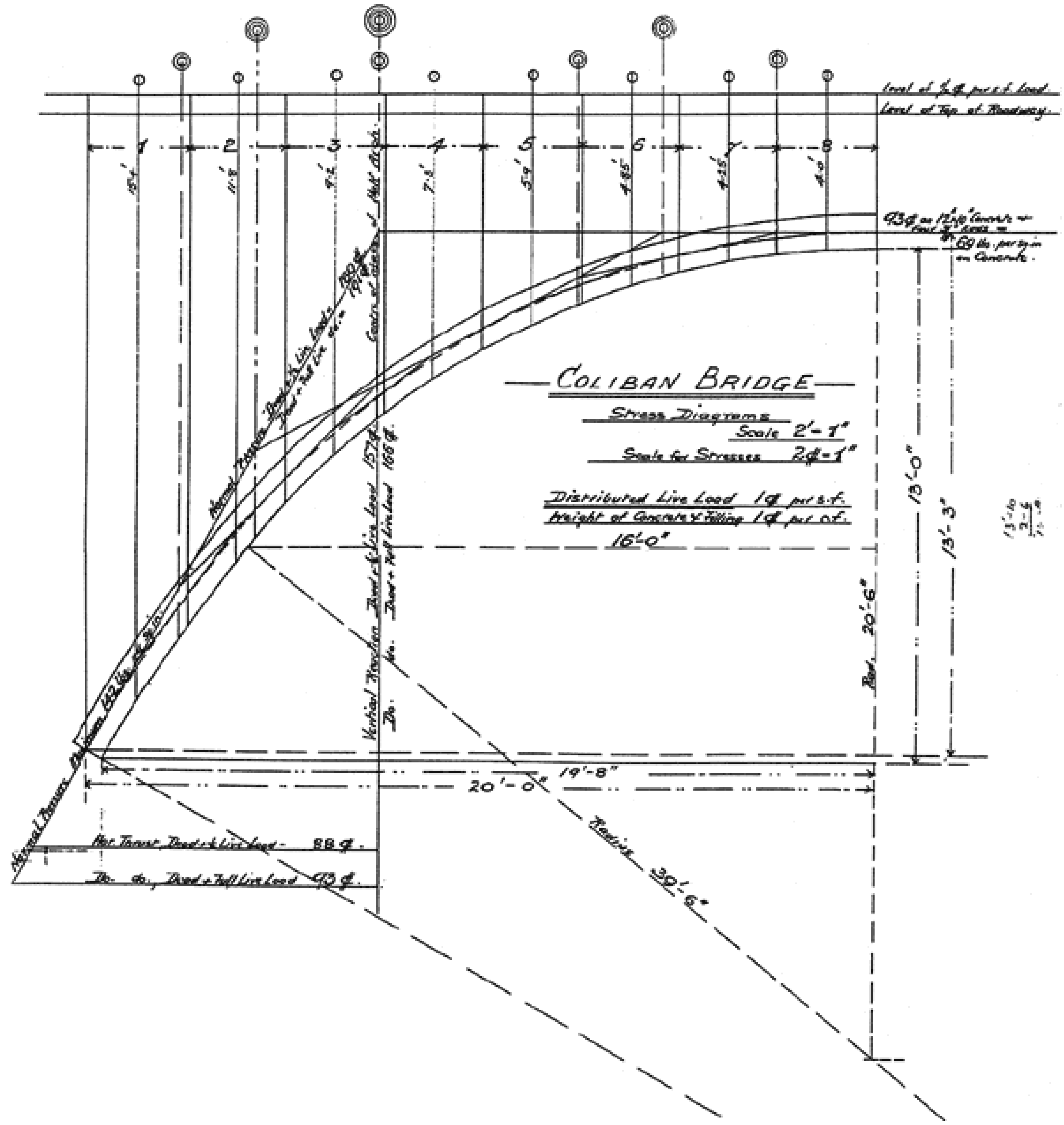
Because of the symmetry, and in the absence of a point load at the crown, H was horizontal. Assuming that the desired form had already been found, both H and R would pass through the centreline of the arch thickness, while W passed through the centroid of the half-arch. The lines of action of three forces which are in equilibrium intersect. Thus R passed through the intersection point of W and H.



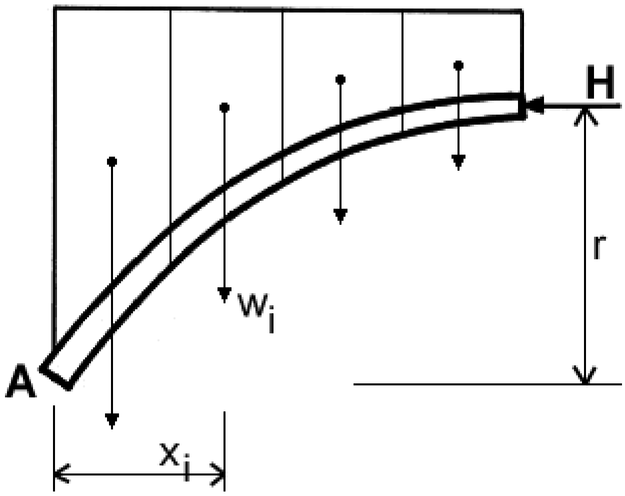
Hence a triangle of forces could be drawn. This gave the direction of R, while the magnitude of R and H could be determined by scaling from the known value of W. (H could also be obtained by taking moments about the abutment.)



This approach is evident in the drawing which J. S. Gregory produced for the Upper Coliban Spillway Bridge. (see below)



In the actual calculation process, the spandrels and fill above the half-arch were conceived as broken into segments by taking vertical slices across the width of the bridge. For clarity, only four are shown in the figure below, but normally eight were taken. It was customary to work with a strip of arch adjacent to the edge and one foot wide. The weight of the live load, when included, was indicated on the drawings as a surcharge comprised of an equally heavy volume of fill. In the Coliban calculations it appears that when the weight of a segment was calculated the specific weights of reinforced concrete, mass concrete, and earth fill were simply taken as a uniform 1 cwt force (112 lbf) per cubic foot (17.6 kN/m^3). When the arch was considered by itself (supporting its own weight during construction, or for an alternative scheme with timber superstructure) the specific weight of 'Monier' was taken as 150 lbf per cubic foot.



Taking moments about the springing point A:

H r = Sum (w_i x_i)

thus
H = (Sum w_i x_i) / r

This approach is evident in the tabular calculations represented below. The same tables permitted the calculation of the total mass above the half-arch (Sum w_i) and the position of its centroid so that the location of the force W could be established.

In the table reproduced below, the effective half-span is taken as 20.08 feet and is split into eight vertical segments each of width K = 20.08 / 8 = 2.51 feet. The centre of gravity of each segment lies at the centroid of its area as seen in elevation. This is assumed to be midway between its vertical edges. The distances from the springing point to each centroid are expressed throughout in terms of K. For a one-foot wide slice in the direction of the span, the volume of each segment is one foot multiplied by its area as seen in elevation, i.e. 1 × K × (average depth). The average depths have been scaled from the drawing as 15.4, 11.8, etc. As the unit weight of all materials is taken as 1 cwt per cubic foot, the weight of a segment is simply 1 × K × (av. depth) × 1 = K × (av. depth). In column 2 the weight W of the one-foot-wide slice of the half-span is summed as 62.62 K = 157.17 cwt. Its first moment about the abutment (Column 3) is 184.29 K^2 = 1161 foot-cwt. Hence the centroid lies 1161/157 or about 7.38 feet from the abutment. With these facts it is now possible to obtain the magnitudes of H and R and the direction of R.

Final set of calculations for Coliban Spillway Bridge "accepted design" with masonry spandrels.

by J.S.Gregory, 21 August 1901 (edited for this website.)
Dead load plus half live load. Span = 39'-4", Rise = 13'.
K = 20.08 / 8 = 2.51

Column 1	Column 2		Column 3		Column 4	Column 5
Lever arm from springing.	Weight of segment.		Moment of weight about springing.		Segments grouped in twos.	Segments grouped in fours.
K × 1/2	15.40 K	27.20	7.70 K^2 17.70	25.40	25.40 K^2 / 27.20 K=	73.95 K^2 / 43.70 K =

K × 3/2	11.80 K		K^2		2.34	4.24
K × 5/2 K × 7/2	9.20 K 7.30 K	16.50	23.00 K^2 25.55 K^2	48.55	48.55 K^2 / 16.50 K = 7.38	
K × 9/2 K × 11/2	5.86 K 4.86 K	10.72	26.37 K^2 26.73 K^2	53.10	53.10 K^2 / 10.72 K = 12.43	110.34 K^2 / 18.92 K = 14.63
K × 13/2 K × 15/2	4.25 K 3.95 K	8.20	27.62 K^2 29.62 K^2	57.24	57.24 K^2 / 8.20 K = 17.52	
	62.62 K		184.29 K^2			

Distance of centre of gravity of whole from abutment point = 184.29 K^2 / 62.62 K = 7.38'
Horizontal thrust = 184.29 × 6.3 / 13.25 = 87.6 cwt.
Vertical Reaction = 157.17 cwt.

In the calculation for horizontal thrust 184.29 × 6.3 / 13.25, the 6.3 is K^2 and the 13.25 is 13'-3", the rise from the abutment "hinge" to the centreline of the arch at the crown i.e. to the level of the horizontal thrust in the crown. The vertical reaction at the abutment must equal the total weight of the segments, 157.17.

To trace the full pressure curve within the arch the vertical slices are grouped first into four groups of two (Column 4). The positions of the centres of gravity is determined for each group. In Column 5 two groups of four segments are taken. This process can be traced through the system of symbols at the top of the drawing, consisting of small concentric circles:

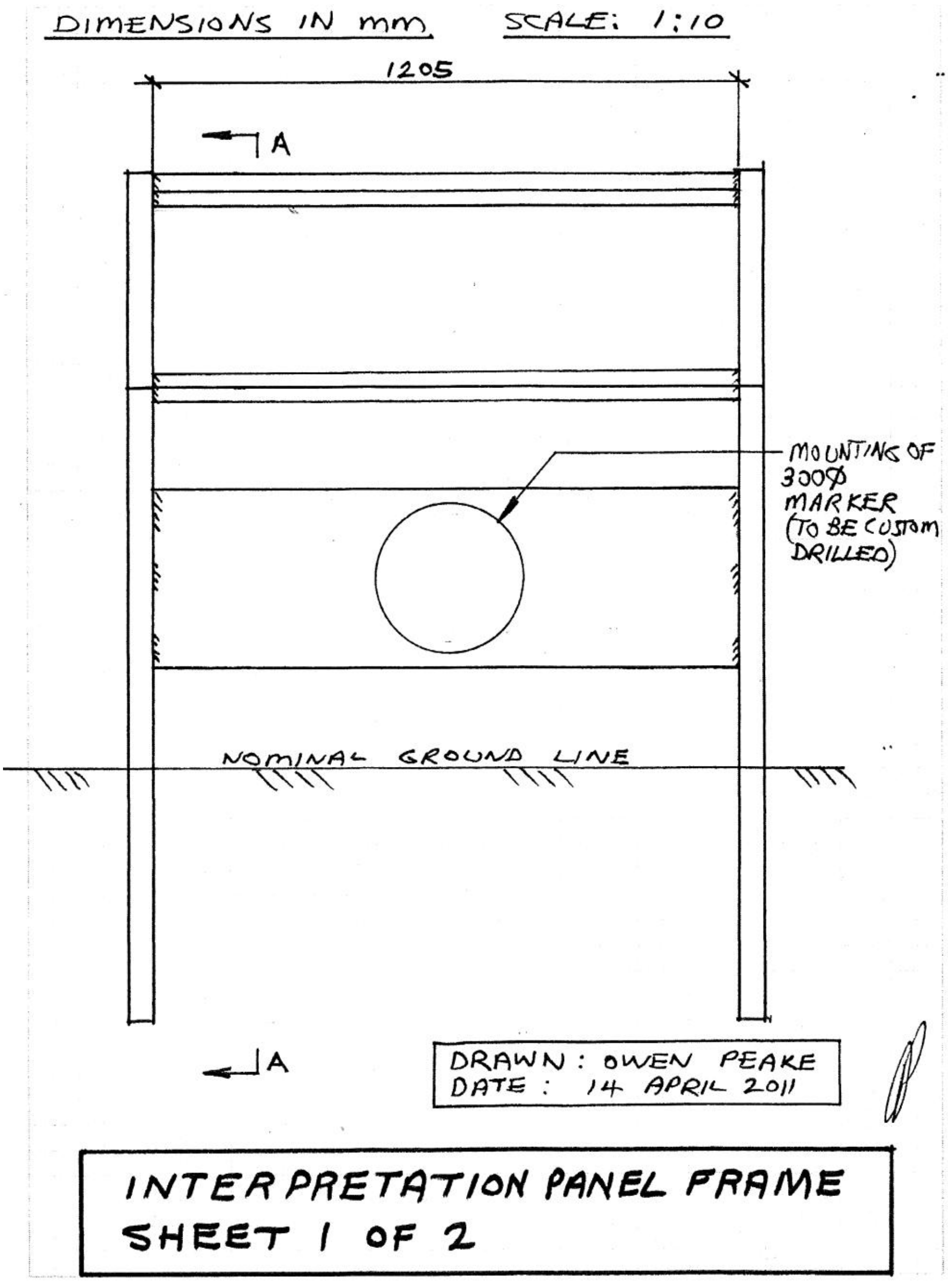
Four small circles indicate the position of the total load W. Part way down its line of action, the intersecting lines of H and R can be seen.

Three small circles indicate the weight of the two groups of four segments. The points where their lines of action cut H and R are joined by a construction line.

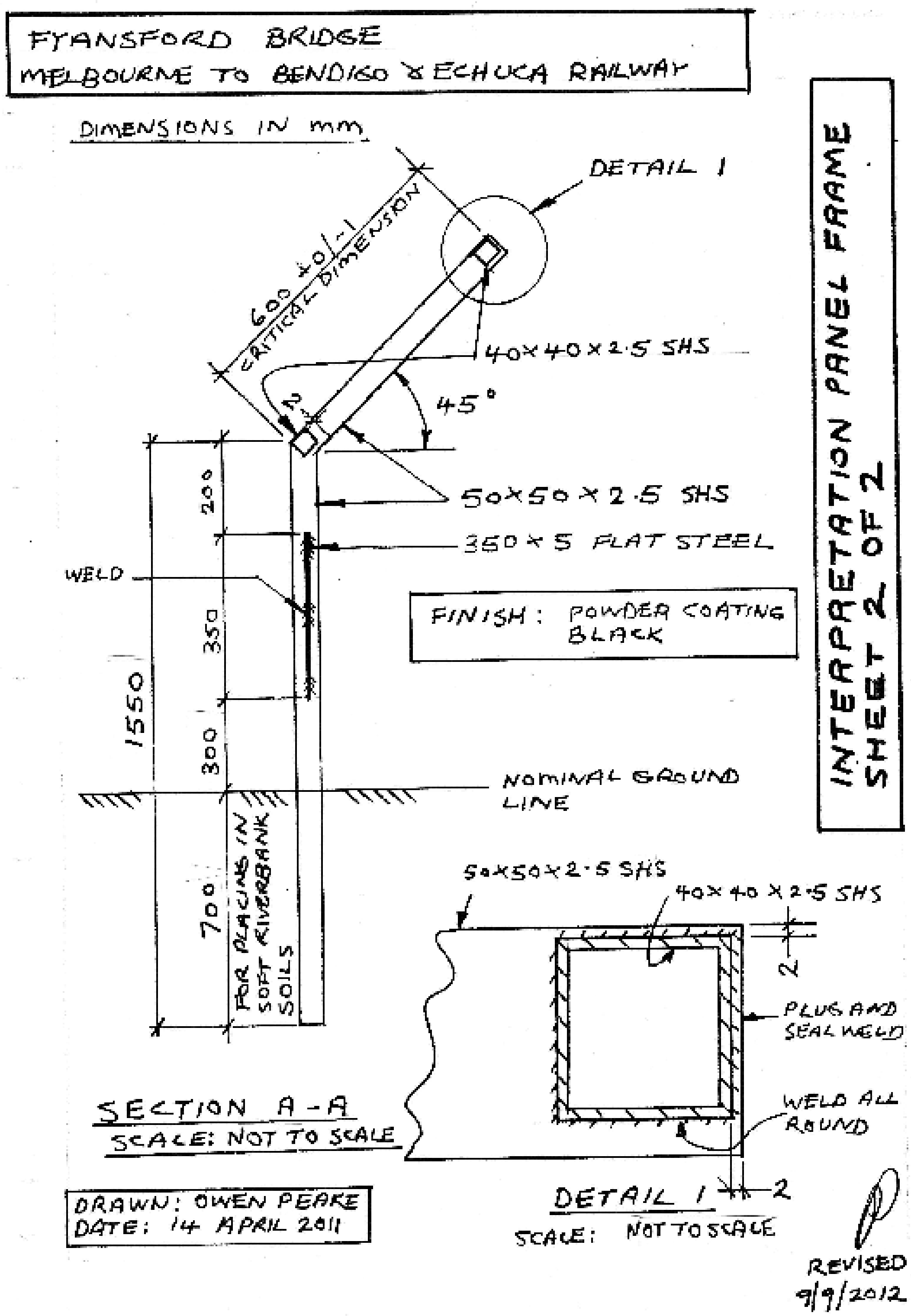
This process is repeated until the level of the individual segment is reached, resulting in the thrust line, shown dashed.

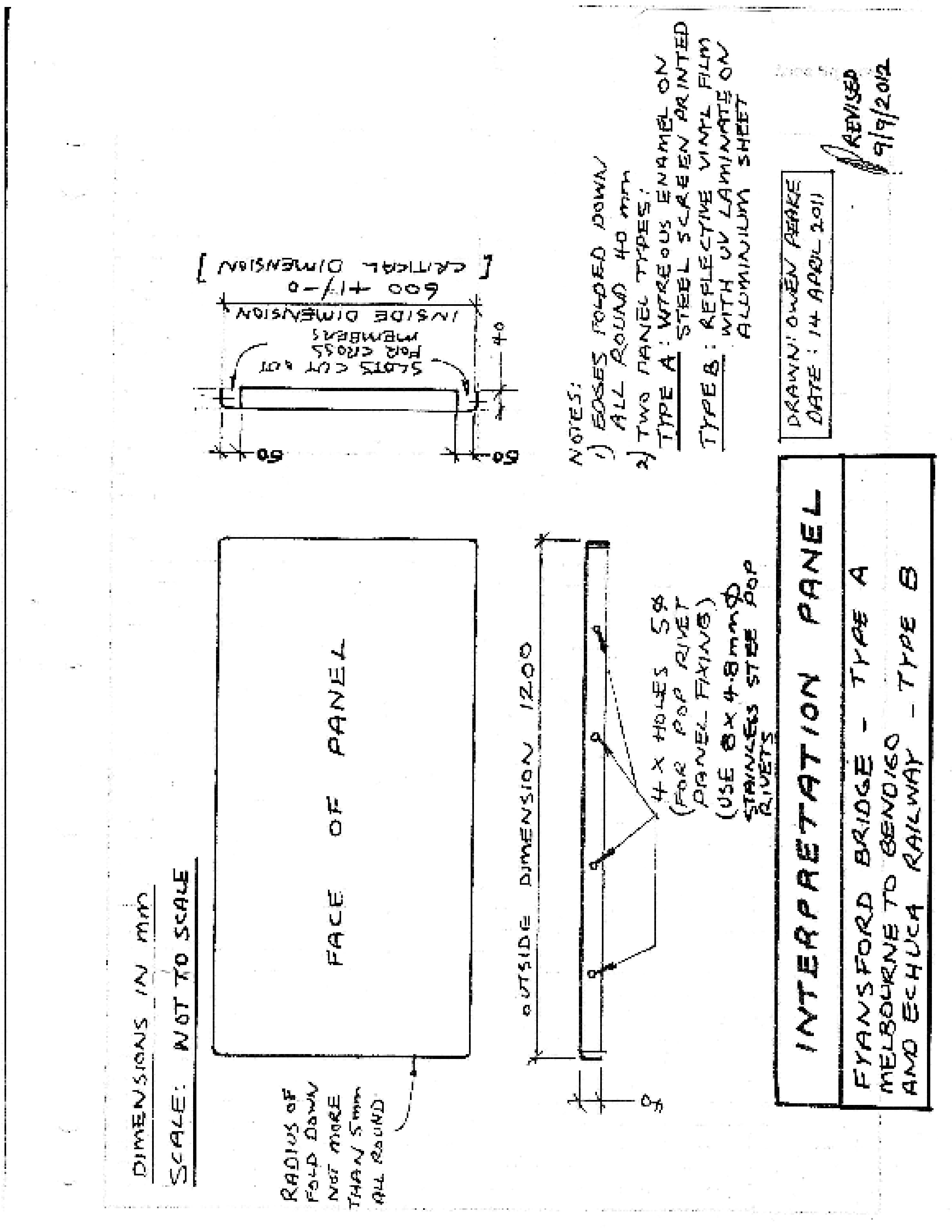
If the thrust curve differed significantly from the initially-assumed profile of the arch, the arch shape would be adjusted to fit the pressure curve, and the calculations repeated using revised segment weights. Generally, only two iterations were needed to achieve satisfactory agreement.

Appendix 9: Interpretation Panel & Mounting Frame Drawings [37]



[37] Note than on the first drawing notes 2 and 3 are incorrect for this site and should be ignored.


FYANSFORD BRIDGE
MELBOURNE TO BENDIGO & ECHUCA RAILWAY
DIMENSIONS IN mm
DETAIL 1
600 +0/-1 CRITICAL DIMENSION
40×40×2.5 SHS
45°
2
50×50×2.5 SHS
350×5 FLAT STEEL
WELD
200
350
300
1550
FINISH: POWDER COATING BLACK
NOMINAL GROUND LINE
700
FOR PLACING IN SOFT RIVERBANK SOILS
INTERPRETATION PANEL FRAME
SHEET 2 OF 2
50×50×2.5 SHS
40×40×2.5 SHS
2
PLUG AND SEAL WELD
WELD ALL ROUND
SECTION A-A
SCALE: NOT TO SCALE
DRAWN: OWEN PEAKE
DATE: 14 APRIL 2011
DETAIL 1
SCALE: NOT TO SCALE
2
REVISED
9/9/2012


DIMENSIONS IN mm
SCALE: NOT TO SCALE
FACE OF PANEL
RADIUS OF FOLD DOWN NOT MORE THAN 5mm ALL ROUND
OUTSIDE DIMENSION 1200
40
4 x HOLES 5Ø (FOR POP RIVET PANEL FIXING)
(USE 8 x 4.8mmØ STAINLESS STEEL POP RIVETS)
50
50
40
SLOTS CUT OUT FOR CROSS MEMBERS
INSIDE DIMENSION
600 +1/-0
[CRITICAL DIMENSION]
NOTES:
1) EDGES FOLDED DOWN ALL ROUND 40 mm
2) TWO PANEL TYPES:
TYPE A: VITREOUS ENAMEL ON STEEL SCREEN PRINTED
TYPE B: REFLECTIVE VINYL FILM WITH UV LAMINATE ON ALUMINIUM SHEET
DRAWN: OWEN PEAKE
DATE: 14 APRIL 2011
REVISED 9/9/2012
INTERPRETATION PANEL
FYANSFORD BRIDGE - TYPE A
MELBOURNE TO BENDIGO AND ECHUCA RAILWAY - TYPE B

CHANGE CONTROL

VERSION 1	**13 MARCH 2013**	**10,472 WORDS**	**COMMENCED DRAFTING. FYANSFORD NOMINATION AS STARTING POINT**
VERSION 2	**15 MARCH 2013**	**10,115 WORDS**	**FURTHER DRAFTING**
VERSION 3	**16 MARCH 2013**	**10,065 WORDS**	**FURTHER DRAFTING**
VERSION 4	**23 MARCH 2013**	**10,065 WORDS**	**ADDED PANEL V1**
VERSION 5	**25 MARCH 2013**	**10,329 WORDS**	**Added quote from The Argus re opening ceremony, clause 3.18.2.**
VERSION 6	**7 APRIL 2013**	**10,649 WORDS**	**MODIFICATIONS TO CLAUSE 3.18, ADDITION OF BIOGRAPHICAL DETAILS FOR J H WHEELER.**
VERSION 7	**12 APRIL 2013**	**10,649 WORDS**	**ADDED MATERIAL HERITAGE OVERLAY CLAUSE 3.19.3**
VERSION 8	**12 APRIL 2013**	**10,512 WORDS**	**ADDED 3 DRAWINGS TO APPENDIX 9**
VERSION 9	**19 APRIL 2013**	**10,940 WORDS**	**ADDED V2 OF PANEL + OTHER MINOR UPDATES**
VERSION 10	**16 MAY 2013**	**11,036 WORDS**	**MINOR UPDATES**
VERSION 11	**19 MAY 2013**	**11,057 WORDS**	**ADDED COUNCIL APPROVAL LETTER**